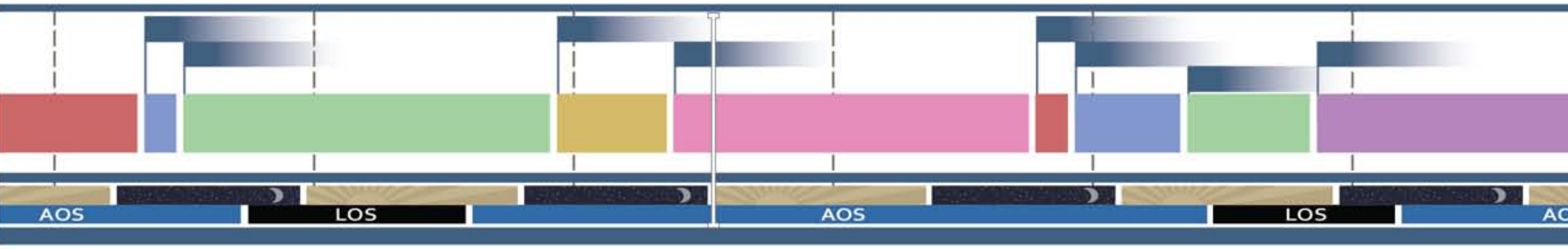


Console Handbook

EVA

Extravehicular Activity Systems

The Extravehicular Activities (EVA) flight controller monitors and assists the crew of the International Space Station (ISS) with spacewalks, or EVAs, task-driven events requiring one or more crewmembers to work outside the International Space Station (ISS).

Special spacesuits are required for spacewalks. The EVA (pronounced *ee-vee-ay*) flight controller monitors the operation of these suits, known as Extravehicular Mobility Units (EMUs). This person also keeps track of additional equipment and systems relating to EVAs, as well as the planned activities for crewmembers while on EVA.

EVA

Extravehicular Activity Systems

Systems Managed: Extravehicular Mobility Unit (EMU) Suit System and the ISS Joint Airlock

Extravehicular Mobility Unit (EMU) Suit System

What is an EMU and what does it do?

The EMU is a human-like suit system which provides the crewmember with protection, mobility (freedom of movement), life support and communications during EVAs. To meet the crewmember's needs during the spacewalk, the EMU features several unique systems which help keep him or her safe and support a successful EVA.

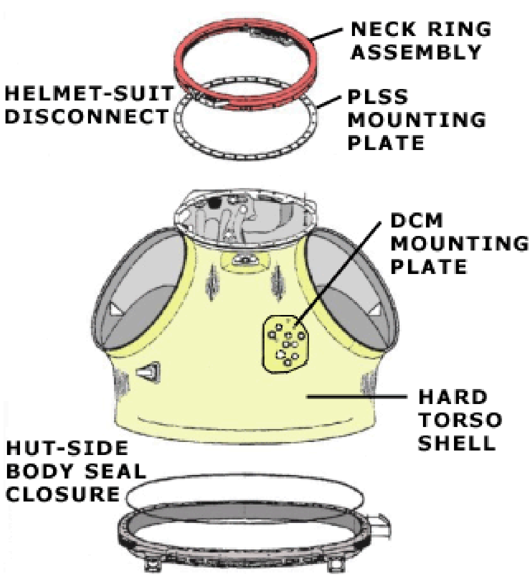
Space Suit Assembly (Pressure Suit)

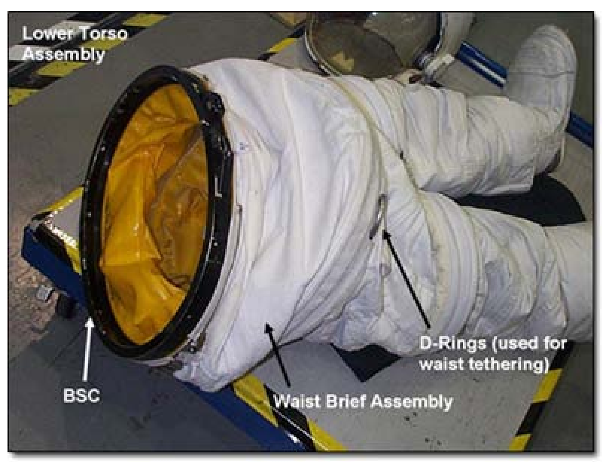
What are the components of the EMU?

The Space Suit Assembly (SSA) has several components which maintain pressure in the EMU and allow for bodily movement. It provides the crewmember with protection from radiation and other elements which can impact the suit, such as very small meteoroids or orbital debris (trash). It also provides insulation, cooling and air (oxygen and gas) circulation. The pictures below provide detail of the suit pieces components of the SSA.

Hard Upper Torso (HUT)

The Hard Upper Torso (HUT) is the part of the suit that is worn above the waist, but does not include the gloves and helmet. *(Pictured below left)*



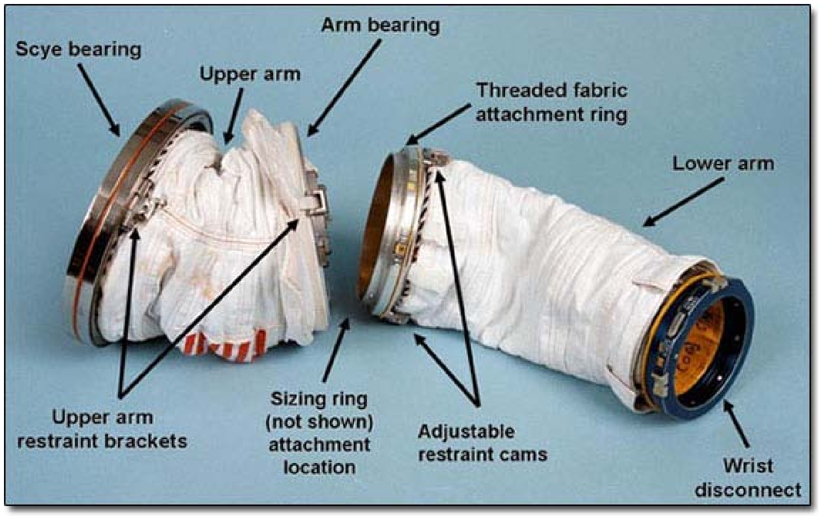


Lower Torso Assembly (LTA)

The Lower Torso Assembly (LTA) is part of the suit worn below the waist, including the boots. *(Pictured above right)*

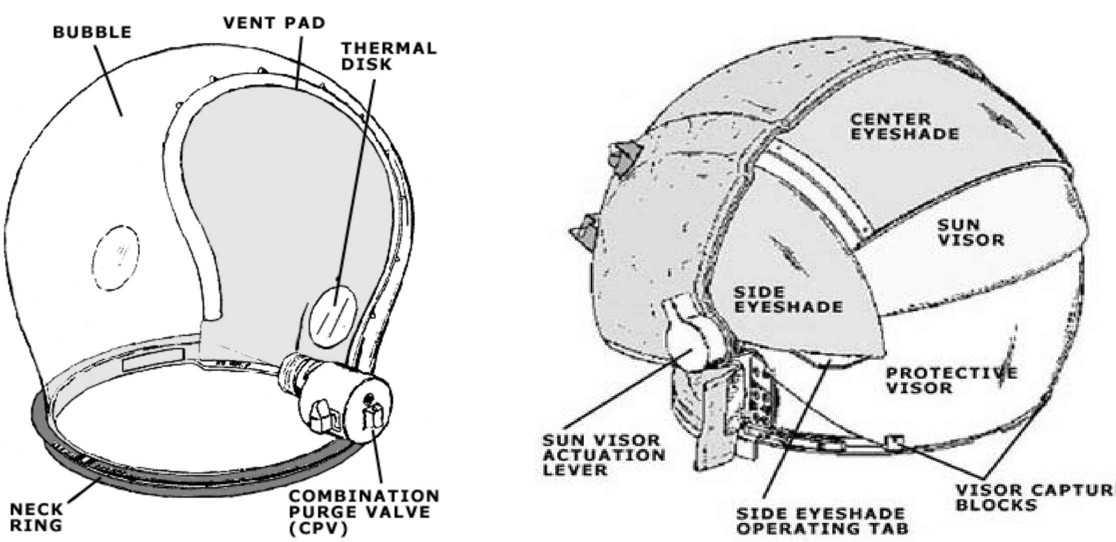
Enhanced Arm Assembly

The Enhanced Arm Assembly is made up of the Enhanced Upper and Lower Arm Assemblies. The Upper Arm Assembly is permanently attached to the Hard Upper Torso and is not normally removed, while the Lower Arm Assembly is removable and can be adjusted to increase or decrease its length. *(Pictured below)*



Helmet and Extravehicular Visor Assembly (EVVA)

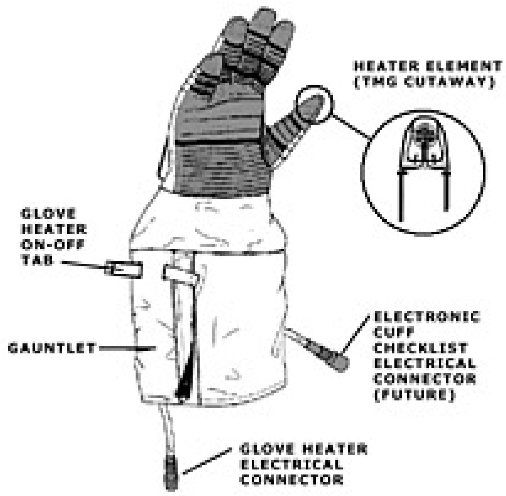
The Helmet and Extravehicular Visor Assembly (EVVA) provides the correct pressure for the crewmember's head. It also shields impacts and glare, and protects the crewmember from the cold. *(Pictured below)*



Front view (left) and rear view (right) of the EVVA Helmet

Glove Assembly

The Glove Assembly has extravehicular, human-like gloves which protect the crewmember's hands. *(Pictured below left)*



Liquid Cooling and Ventilation Garment (LCVG)

The Liquid Cooling and Ventilation Garment (LCVG) is worn under the suit and has flexible tubes (known as cooling loops). These cooling loops circulate cool water over the crewmember's body and are used to help remove excess body heat. While the cooled water typically maintains a constant temperature (around 35º F), crewmembers are still able to control their cooling to a comfortable level. This is done by adjusting a valve located on the front of the suit on the Display and Control Monitor (DCM) which can slow or increase the pressure of circulating water. *(Pictured above right)*

Operational Bioinstrumentation System (OBS)

It can take up to eight hours to complete an EVA, which can be very physically demanding for the crewmember. To medically monitor the crewmember during an EVA, the EVA flight controller oversees the Operational Bioinstrumentation System (OBS), which provides real-time information on heart rate to the flight surgeon console. (The flight surgeon is the mission-assigned medical doctor.) The EVA flight controller ensures that the hardware is correctly transmitting the required data.

The OBS is used to detect any abnormal electrocardiograph (ECG) signals from the crewmember. An ECG is an instrument which will record changes in the electrical potential during a heartbeat. As part of the OBS, the crewmember's ECG signals are sent to a radio, located within the EMU. The radio then sends the ECG signal to the EVA flight controller and the flight surgeon. As the flight surgeon monitors the crewmember's heart rate, the EVA flight controller monitors the power signal. In the event the surgeon stops receiving ECG data, the flight controller can alarm the flight surgeon of any problem with the ECG device.

Communications Carrier Assembly (CCA)

While on EVA, the crewmember must be able to communicate with supporting personnel on the ground, the ISS and with other extravehicular crewmembers. Worn under the EMU helmet, the Communications Carrier Assembly (CCA) provides the crewmember with earphones and microphones, and allows the crewmember to receive Caution & Warning (C&W) tones.

Life Support System (LSS)

How is a livable environment maintained during an EVA?

The Life Support System (LSS) is made up of a group of smaller systems (subsystems) which work together to provide a livable environment inside the EMU.

These subsystems supply oxygen, stabilize pressure and create air movement (ventilation) for the EMU. They help keep the crewmember at a comfortable temperature, and allow him or her to read EMU data, control EMU functions and communicate with others.

Primary Life Support Subsystem (PLSS)

The Primary Life Support Subsystem (PLSS) is the backpack assembly which provides the EVA crewmember with oxygen for breathing, ventilation and stable pressure. This backpack provides water for the cooling loops inside the EMU and it also contains sensors which allow the EVA flight controller to monitor water temperature data during an EVA.

Using a cable, the PLSS can also be connected to a laptop to provide the EVA flight controller with additional data during EMU-powered activities, such as maintenance and system testing.

The EVA flight controller will monitor, plot, and compare data, and determine if the EMU is working as expected. In the event of any difficulty, the EVA flight controller will address and correct any problem.

Secondary Oxygen Pack (SOP)

The Secondary Oxygen Pack (SOP) is a backup which provides oxygen for breathing, ventilation, stable pressure and cooling, in case there is a problem with the primary oxygen tanks or if there is a suit leak. It is located at the bottom of the PLSS and is bolted on, but can be replaced when required.

A sensor on the SOP provides data, allowing the EVA flight controller to determine if the backup system will provide enough oxygen, and if it will work properly.

Contaminant Control Cartridge (CCC)

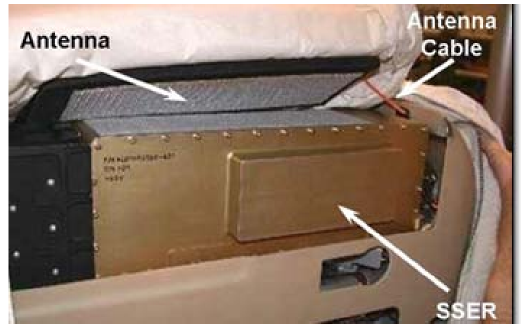
The Contaminant Control Cartridge (CCC) keeps carbon dioxide, odors, particulates (very small particles) and other contaminants from getting into the ventilation of the EMU. The carbon dioxide sensor in the EMU provides notification if the cartridge begins to be used up during an EVA.

EMU Battery

The EMU battery, a removable, rechargeable lithium-ion battery, supplies power to the EMU to enable communication, circulation of oxygen and removal of carbon dioxide through a fan.

Sensors inside the suit provide the EVA flight controller with the battery voltage and amperage (the amount of electrical energy flowing through an appliance) during an EVA. The EMU battery provides only a certain amount of amperage per hour on a full charge. As the battery starts to run out, the EVA flight controller will calculate how much time the systems in the suit have to continue working. *(Pictured right)*

Space-to-Space EMU Radio (SSER)



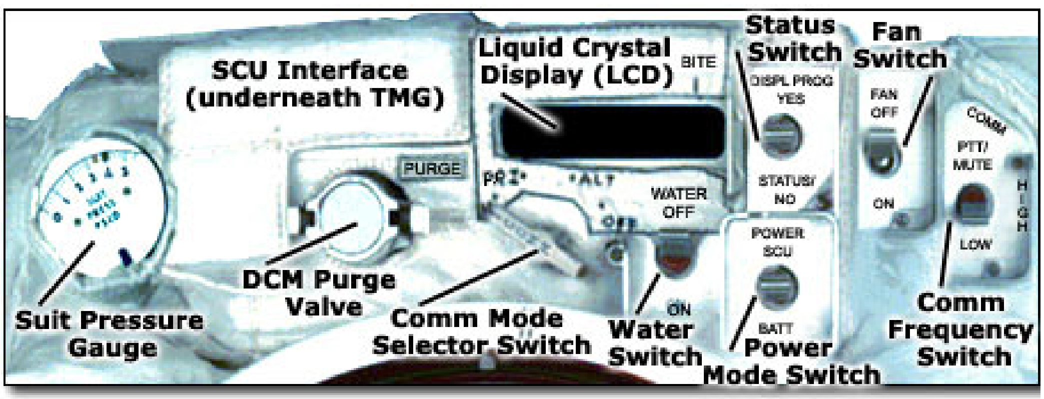
The Space-to-Space EMU Radio (SSER) includes a radio transmitter-receiver (or transceiver) and an antenna, both of which provide voice and data communication in the EMU for the crewmember. The radio connects with the radio on the ISS, and sensors inside the suit transmit data on the status of the systems to the EVA flight controller. *(Pictured right*)

The SSER also receives Caution & Warning (C&W) information from any data systems in the EMU, which is also sent to the EVA flight controller.

Display and Control Module (DCM)

The Display and Control Module (DCM) is where the EVA crewmember interacts with the Primary Life Support Subsystem (PLSS). It contains displays and controls for the operation of the EMU and is attached to the front of the upper torso of the EMU.

In order to read the displays at this location, the crewmember uses mirrors (attached to the arms of the EMU) to reflect and read the information, which is written backward on the front of the suit. Sensor readings are provided to the crew and read on the top of the DCM on the Liquid Crystal Display (LCD). *(Pictured below)*



The ISS Joint Airlock

Where are EMUs stored and maintained?

The ISS Joint Airlock (or joint airlock) allows the EVA flight controller to support preparation and servicing of the EMUs before and after the EVAs. The joint airlock consists of two modules, the Equipment Lock (E-Lk) and the Crew Lock (C-Lk). This is where the EMUs are serviced, maintained and stored. There is also storage space for additional hardware, wired communication support between ISS modules, and access to outside the ISS. The EVA flight controller monitors data from the hardware in these modules to help oversee crew activities.

Equipment Lock (E-Lk)

Where do crewmembers start "powering up" for a spacewalk? What equipment is necessary?

All EMUs are put on or taken off in the E-Lk. It is where they can be recharged and serviced and where any activity which requires spacesuits to be buttoned and pressurized takes place. The E-Lk also provides a place to store a variety of EVA-related equipment. Additionally, the E-Lk enables crewmembers to "power up" the EMUs in preparation for an EVA.

Power Supply Assembly (PSA)

The Power Supply Assembly (PSA), housed in the E-Lk, powers spacesuits used during an EVA from the joint airlock. It can power two EMUs along with supply power to other equipment. The PSA is powered by Remote Power Controllers aboard the ISS, and the EVA flight controller ensures these power sources are available before any hardware in the joint airlock is used.

When powered, the PSA sends power to six assigned channels, up to two of which are EMU spacesuits. It also features a switch which allows the crew to "suit select" a specific EMU as its power destination. This data is provided to the EVA flight controller so the procedural steps can be tracked without interrupting the EVA crewmember for status updates.

Battery Assemblies

EMU batteries are charged by the Battery Charging Assembly (BCA) and stowed (stored) in the Battery Stowage Assembly (BSA) when awaiting use by the crew for an EVA.

Once the batteries are placed in the BSA and the BCA is turned on, the EVA flight controller receives a status message indicating a normal reading. The voltage and amperage for each charger are displayed on the EVA flight controller's display screen (console), indicating the charge level of the batteries.

In-Flight Refill Unit (IRU)

To fill or refill an EVA crewmember's water supply, the In-Flight Refill Unit (or IRU, also known as the Fluid Pumping Unit) is used to draw water from a bag called the Portable Water Reservoir (PWR). This water is then delivered to the EMU water tanks.

The EVA flight controller determines when the IRU has been powered up, and that a water refill is being completed.

Common Cabin Air Assembly (CCAA)

The Airlock Common Cabin Air Assembly (CCAA) provides atmospheric conditioning (air conditioning) to crewmembers in the E-Lk. This assembly can circulate the air, regulate temperature, and remove small particles, moisture, and carbon dioxide from the joint airlock during various airlock activities, including when isolated in the airlock and when depressurized to lower pressures than the rest of ISS.

The EVA flight controller monitors the oxygen, nitrogen and carbon dioxide levels within the joint airlock during EVA activities, ensuring that a safe atmosphere for the crew is maintained. In case too much oxygen is released into the atmosphere of the joint airlock during an EVA activity, the EVA flight controller will collaborate with the ETHOS (Environmental and Thermal Operating Systems) flight controller.

Metox Canisters

Each EMU has a Metox Canister – a container with metal oxide sheets inside which remove carbon dioxide (CO_2). Periodically, the Metox Canister must release the captured carbon dioxide. This release is a sort of “recycling”, and is done by heating the carbon dioxide to 450 °F (232 °C) for ten hours.

Carbon dioxide containers in the E-Lk allow the CCAA and Metox Canisters to interact by providing a location other than the spacesuit to install them for CO_2 removal.

Depress Pump

Prior to an EVA, the Crew Lock (C-Lk) provides an accessible vacuum (an unpressurized environment) for two, suited EVA crewmembers and their EVA equipment. To achieve this vacuum, a Russian-provided pump in the E-Lk (called the Depress Pump) is used to perform a depress process. The data received from this pump is monitored by the EVA flight controller.

The “depress” begins with the Depress Pump independently moving the stack pressure (or starting pressure) down to 5 pounds per square inch (psi). Once the atmosphere reaches 5 psi, the Depress Pump and a valve (known as the Vent Relief Valve) are both opened to continue the depress process at an appropriate rate. The atmosphere eventually reaches 2 psi and is then recycled back to the ISS. While the Depress Pump is switched off, the valve is left open until a vacuum (0 psi) is achieved. Completion of this process allows the airlock hatch to be opened and enables the crew to go outside.

Crew Lock (C-Lk)

When are the EMU suits ready for an EVA?

The “powering up” process starts with the crewmember setting one or more EMUs on battery power and moving a series of switches. These switches power up the Power Supply Assembly (or PSA, located in the E-Lk), and send power downstream to the Umbilical Interface Assembly (or UIA, located in the Crew Lock). As more power switches are switched on in the Crew Lock (C-Lk) UIA, the Service and Cooling Umbilical (or SCU) becomes energized. At last, the EMU power switch is moved from the battery position to the SCU position, so that is can accept power from the joint airlock. This “powering up” allows the EMU to provide power, oxygen and hard-line communication for the crewmember while in the joint airlock.

Throughout this sequence, the volts and amperage provided at the PSA and UIA are displayed on the Joint Airlock Mega Display in the Mission Control Center and is monitored by the EVA flight controller. This data provides the flight controller with an ability to follow the crew’s progress during power up, and provides situational awareness to the team on what the crew is doing.

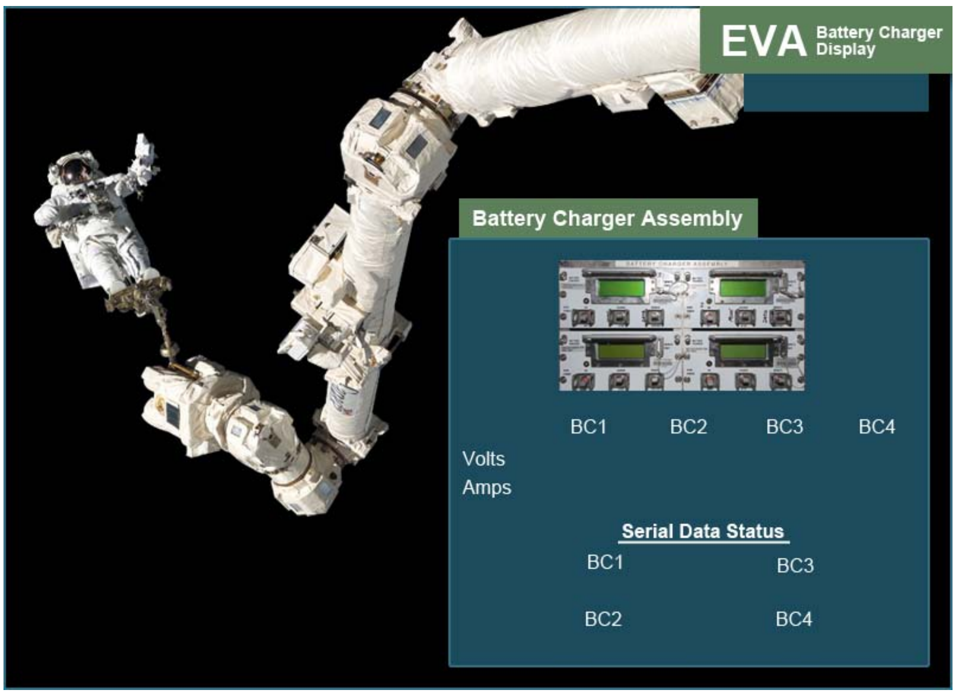
The EVA flight controller monitors whether the UIA is on, and is informed of the voltage and amperage that the UIA is receiving. This informs the flight controller whether the hardware is actively drawing current, and if it is running on vehicle power (from the PSA). If no amperage is being drawn, but the EVA flight controller is still receiving data from the EMU, then it can be confirmed that the suit is using battery power.

It is not until the crew exits the joint airlock and moves outside the ISS into space that the UIA is removed and the EMU begins running on battery power for the remainder of the EVA.

To learn more about the EVA systems on the ISS, return to the International Space Station *Live!* (ISS*Live!*) website at http://spacestationlive.jsc.nasa.gov. Select "Interact", and then select "Visit Space Station".

EVA Console Display

A wireless signal sends data from the ISS to the Mission Control Center. This data is updated on the EVA console display. The EVA flight controller checks the data on the console display to make sure everything is working as expected.



Pictured above is a simplified version of the EVA console display. Data shown provides volts and amps data for battery charging activities. This allows the EVA flight controller to confirm that batteries are being charged, as well as determine a Serial Data Status value of "normal" when the charger is turned on. To view this display, return to the ISS*Live!* website at http://spacestationlive.jsc.nasa.gov. Select "Interact", and then select "Explore Mission Control".

Space Station Live Data

Would you like to know more about the live data streaming from the ISS to the EVA console display? Return to the ISS*Live!* website at http://spacestationlive.jsc.nasa.gov. Select "Resources", and then select "Space Station Data". There you will find a table which includes the names and brief descriptions of all the data values used to update the interactive Mission Control Center console displays.

Acronyms and Abbreviations

BCA	Battery Charging Assembly
BSA	Battery Stowage Assembly
C-Lk	Crew Lock
C&W	Caution & Warning
CCA	Communications Carrier Assembly
CCAA	Common Cabin Air Assembly
CCC	Contaminant Control Cartridge
DCM	Display and Control Module
E-Lk	Equipment Lock
ECG	Electrocardiograph
EMU	Extravehicular Mobility Unit
ETHOS	Environmental and Thermal Operating Systems
EVA	Extravehicular Activities
EVVA	Helmet and Extravehicular Visor Assembly
HUT	Hard Upper Torso
IRU	In-Flight Refill Unit
ISS	International Space Station
LCD	Liquid Crystal Display
LCVG	Liquid Cooling and Ventilation Garment
LSS	Life Support System
LTA	Lower Torso Assembly
OBS	Operational Bioinstrumentation System
PLSS	Primary Life Support Subsystem
PSA	Power Supply Assembly
PWR	Portable Water Reservoir
SCU	Service and Cooling Umbilical
SOP	Secondary Oxygen Pack
SSA	Space Suit Assembly
SSER	Space-to-Space EMU Radio
UIA	Umbilical Interface Assembly